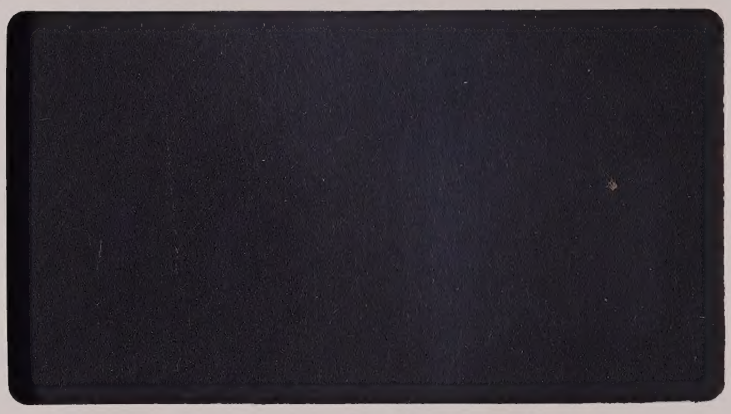
INSTRUCTION MANUAL

Gertsch*

Models NI-2 and NI-3

Null Indicators

SINGER
INSTRUMENTATION



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SINGER INSTRUMENTATION

Precision electrical and electronic instruments for measurement

emc — EMPIRE* — Gertsch* — Panoramic* — Sensitive Research*

THE SINGER COMPANY • METRICS DIVISION

*A Trademark of THE SINGER COMPANY

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*Sensitive Research** Electrical Indicating Instruments.....2 years
Other Electrical and Electronic Measuring Instruments.....1 year

Repair or replacement (at our option) without charge (F.O.B. factory) will be effected when our examination satisfactorily indicates that defects are due to workmanship or materials. Electron tubes, semiconductors, batteries, fuses, lamps, thermoelements, and *RatioTran** potentiometers are excluded from warranty coverage. Warranty returns must first be authorized by the factory.

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Instruments should be returned only on prior written authorization from the Singer Representative or the factory(1). Warranty repair will be made upon written request. Please provide the following information in order to expedite our processing of your instrument:

1. Model or Type
2. Serial Number
3. Description of trouble(2)
4. Test instruments used
5. Approximate date instrument was placed in operation
6. Approximate number of hours of use
7. Has maintenance action been previously requested?
8. Other comments

Upon receipt of this information our Service Department will send you service data or shipping instructions. Upon receipt of shipping instructions forward the instrument to the factory prepaid. If requested, an estimate of charges will be made before work begins.

(1) Contact Metrics Division, Bridgeport, Connecticut for *Empire**, *Panoramic**, and *Sensitive Research** instruments. Contact Metrics Division, Los Angeles, California for *Gertsch** instruments.
(2) Include data on symptoms, measurements taken, suspected location of trouble, maintenance action taken, and any other relevant data.

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Figure 1-1. Model NI-2 and NI-3 Null Indicators

SECTION I
GENERAL DESCRIPTION

1-1. Models NI-2 and NI-3R are phase-sensitive null indicators that may be combined with any standard Gertsch Ratiotran to form an ac ratio bridge. Three ranges of sensitivity are provided. A maximum sensitivity of 10 microvolts allows excellent resolution for bridge circuit operation.

1-2. The NI-2 is supplied in a portable carrying case and is battery operated, hence stray capacity and ground-loop measuring problems are eliminated. Model NI-3R, a 3-1/2 inch high rack mounted version, contains an internal ac power supply.

1-3. Both instruments feature a phase-sensitive detector which provides quadrature rejection. A zero-center meter gives the operator "sense" as to being above or below null.

1-4. Model NI-2 can also be used as an amplifier over the frequency range of 25 cps to 100 KC, with three ranges of gain: 50, 500, and 5000. These small-size instruments are ideal for laboratory, production or field applications.

TABLE 1. SPECIFICATIONS

Type	Phase Sensitive
Frequency Range	50-10,000 cps
Sensitivity	3 ranges: 10uv, 100uv, 1000uv
Input Impedance	1 megohm minimum
Ref. Voltage Amplitude	
3 ranges: 1-5v	0.35 f (f in cps)
5-25v	max. (21 volts
25-125v	@ 60 cps)
Power	
NI-2	2 internal 9v batteries with 140 hrs life
NI-3R	Internal ac supply
Indicator	Zero center null meter
Size	
NI-2	12" x 7" x 5" deep
NI-3R	19" x 3-1/2" x 7" deep

SECTION II
OPERATING INSTRUCTIONS

2-1. GENERAL.

2-2. A typical application of a null indicator is shown in figure 2-1. The two test instruments from an ac bridge circuit in which the null indicator compares the output of the ratiotran to the output of the unit under test. In this application, the Ratiotran is adjusted until a null is indicated. The output to input voltage ratio of the unit under test may then be read from the settings of the ratiotran.

2-3. OPERATION.

2-4. To operate the null indicator, proceed as follows:

a. For Model NI-2 only, turn FUNCTION switch to the BAT CHK position and check that meter deflects to or above the red line. If deflection is below the red line, replace the batteries.

b. Determine the voltage amplitude of the reference source and set the FUNCTION switch (NI-2) or REFERENCE switch (NI-3) to correspond to the reference voltage. Make certain the input voltage is less than 0.35 times the frequency in cps of the reference signal or 125 vrms, whichever is less. Connect reference source to REFERENCE INPUT jacks.

NOTE

A reference input is not required when the unit is used as an amplifier only.

c. Turn SENSITIVITY switch to the desired position.

d. Connect comparison signals to the SIGNAL INPUT jacks.

e. For Model NI-3 only, turn POWER switch ON.

f. With the ratiotran set to zero ratio, set METER REVERSAL switch so that the meter deflects to the left of the center null position.

g. Adjust ratiotran as required to obtain a null on the meter. At null, read the output voltage ratio of the unit under test from the setting of the Ratiotran.

2-5. NOTES ON OPERATION.

2-6. SENSITIVITY SWITCH. For maximum resolution, turn the switch to the X1.0 position. In this position however, a number of factors can obscure the null point (see below). If the null point is obscured, turn the switch to the X.10 or even the X.01 position to obtain a clearly defined null.

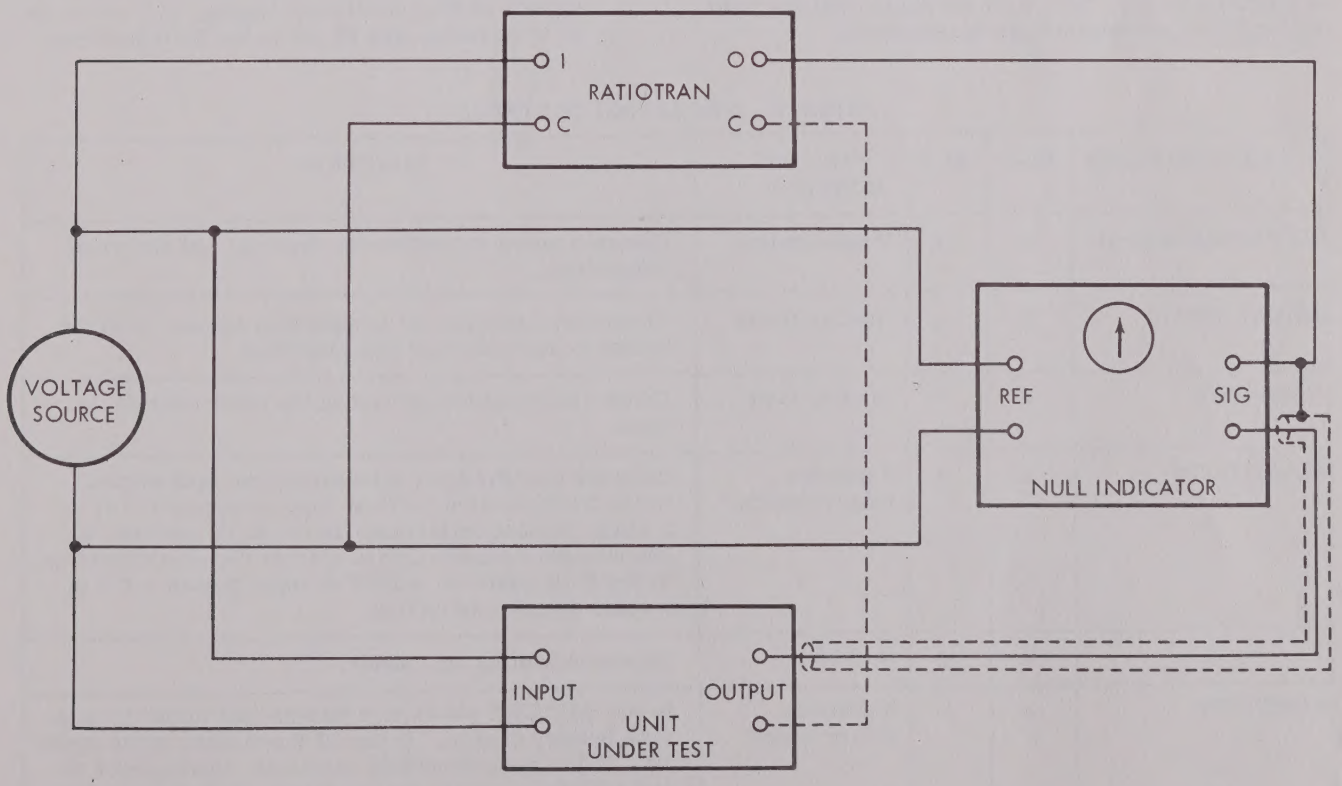


Figure 2-1. Typical Application

2-7. During a test, the smallest signal change available may cause a large deflection of the meter movement. As an example, if a Gertsch RT-5 ratiotran is placed in the bridge circuit each step of the sixth place on the ratiotran is equal to $E_{in} \times 10^{-6}$. If E_{in} is 100 volts, each position of sixth place is 100 uv. With a meter sensitivity of 20 uv per division, a one step change at the sixth place on the RT-5 will result in a needle deflection of five divisions on the null meter. If a five place ratiotran is inserted instead, a one step change in the last place would be equal to 1000 uv or full scale meter movement, Placing the sensitivity switch in X.10 position will provide the necessary attenuation for easier balancing of the bridge.

2-8. Noise or instability in either the signal or reference inputs can cause excessive meter movement and obscure null points. If the sensitivity switch is placed in either the X.10 or X.01 position, the fluctuations will be reduced by a factor of 10 or 100.

2-9. Distortion in the reference voltage source can cause erroneous readings. Although the ratiotran and null indicator will operate satisfactorily with a distorted reference voltage, the distortion may have a different effect on the unit under test than on the reference circuitry. One result could be apparent phase shift.

2-10. The null indicator reacts only to the fundamental in-phase component of the input signal. Any phase shift through the unit under test can obscure the null points or even cause erroneous readings. Assume an output voltage of 100 vrms and a phase shift of 0.01° through the unit under test. The null indicator reacts to the in-phase component leaving a quadrature component of approximately 17 mv. A 17 mv signal will overload the amplifier and obscure the in-phase null.

2-11. CASE GROUND JACK. The outer chassis, or case, is isolated from circuit common to eliminate stray capacity and ground loop problems. In some test setups, the outer case can develop a potential and therefore should be connected to an external ground.

2-12. To reduce stray capacity and voltage pickup errors to a minimum, use a shielded cable from the output of the unit under test and drive the shield with the output of the ratiotran. At null, the inner and outer conductors will be at the same potential.

2-13. If the unit under test (or the test setup) produces a 180° phase shift, a null cannot be obtained. If a 180° phase shift is known or suspected, reverse the reference voltage input to the ratiotran.

2-14. AMPLIFIER OPERATION. To operate the Model NI-2 as an amplifier, proceed as follows:

a. Turn FUNCTION switch to the BAT CHK position and check that meter deflects to or above the red line. If deflection is below the red line, replace the batteries.

b. Connect input signal to the SIGNAL INPUT jacks.

c. The amplified signal is available at the auxiliary output jacks, located on the back of the unit.

d. Turn FUNCTION switch to any one of the REF positions.

e. Turn SENSITIVITY switch to the desired position. In the X1.0 position, the null indicator will amplify signals of 250 uv without clipping, 2.5 mv in the X.10 position, and 25 mv in the X.01 position.

TABLE 2. OPERATING CONTROLS

PANEL MARKING	NI-2	NI-3	TYPE OF CONTROL	FUNCTION
METER REVERSAL	x	x	Toggle switch	Controls meter deflection for overnull and undernull indications.
SIGNAL INPUT	x	x	Binding Posts	Connection point for the comparison signals from the bridge or for a signal to be amplified.
CASE GND	x	x	Binding Post	Connection point for grounding the outer chassis, or case.
SENSITIVITY	x	x	3 position rotary switch	Controls sensitivity by attenuating the input signal. In the X1.0 position, a 10 uv input causes a 1/2 of a scale division deflection. In the X.10 position, a 100 uv input causes a 1/2 of a scale division deflection. In the X.01 position, a 1000 uv input causes a 1/2 of a scale division deflection.
	x	x	Null Meter	Center indicating null meter.
FUNCTION	x		5 position rotary swich	In the BAT CHK position, connects null meter to measure battery charge. In the OFF position, turns power off. In the remaining REF positions, turns power on and adjusts circuit to the amplitude level of the reference voltage source.

TABLE 2. OPERATING CONTROLS (CONT)

PANEL MARKING	NI-2	NI-3	TYPE OF CONTROL	FUNCTION
REFERENCE		x		Adjusts circuit to the amplitude level of the reference voltage source.
POWER		x		Power on-off switch.
REFERENCE INPUT	x	x		Connection point for a reference input voltage.
	x		Auxiliary output jacks	Output point for an amplified signal.

SECTION III
THEORY OF OPERATION

3-1. GENERAL. (See figure 3-1.)

3-2. The null indicator basically consists of a transsistorized, high gain, wide band amplifier driving a phase sensitive detector. An isolation transformer provides an in-phase voltage, derived from the bridge input signal, as reference to the detector. The detector is then sensitive only to the in-phase component of the null signal.

3-3. In a typical bridge setup as shown in figure 3-1, the reference voltage is applied to the unit under test and to a voltage divider such as a Gertsch Ratiotran. The output of the unit-under-test is applied to the signal input jack and the output of the ratiotran is applied to the signal input common.

3-4. The chassis of the null amplifier is completely floating and functions as the common for the input signal. When the voltage output of the ratiotran exactly equals the output of the unit under test, no potential exists between the two inputs and therefore the output of the null amplifier is a minimum or null.

3-5. NULL DETECTOR. (See figure 3-2.)

3-6. The null detector operates as an ac bridge which is sensitive to phase differences. When the voltage across points A and C is exactly 90° out-of-phase with the voltage across points B and D, the voltage differential between points A and C is minimum. Therefore when the signal received from the null amplifier is either minimum or 90° out-of-phase with the reference voltage, the bridge detects a null.

3-7. Assuming the input signal to the unit to be 1° out-of-phase with the reference voltage and the ratiotran to be set to zero, the null detector will detect a voltage. As the ratiotran is adjusted to apply ever increasing amounts of inphase voltage to the null amplifier chassis, the resultant signal contains diminishing amounts of inphase components. When the output of the ratiotran exactly equals the inphase component of the input signal, the resultant signal contains only a quadrature component. This resultant signal is amplified by the null amplifier and applied to points A and C of the null detector. Since this signal is exactly 90° out-of-phase with the reference voltage, meter M101 indicates a null. The amount of in-phase voltage required to achieve a null is indicated by the setting of the ratiotran.

3-8. Meter M101 is a center null meter, connected to deflect to the left of center when an in-phase voltage is present. If, instead, the meter deflects to the right, this indicates that the reference and signal voltages are 180° out-of-phase. In this case, METER REVERSAL switch may be used to reverse the meter deflection.

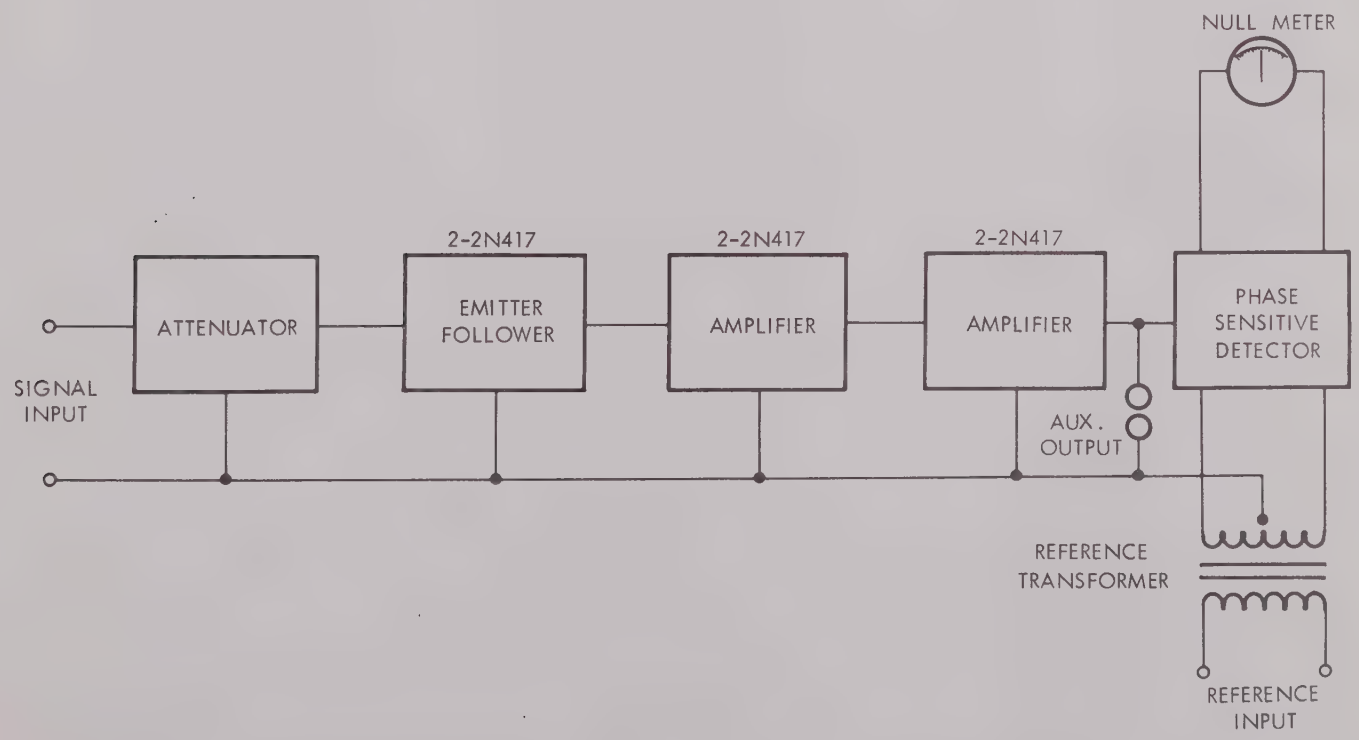


Figure 3-1. Block Diagram

3-9. NULL AMPLIFIER. (See figure 3-3 or figure 3-4.)

3-10. The input signal is applied either directly to the input stage or to a divider network by the SENSITIVITY switch S101. In the X1.0 position, the signal is applied directly. In the remaining two positions, the signal is attenuated by the resistor network consisting of resistors R101 through R103. The capacitor network C101 through C104 adjust and improve the high frequency response of the network.

3-11. Large off-null signals are limited by back-biased diodes CR101 and CR102. Resistor R105 limits the off-null current drain. Transistors Q101 and Q102 are connected as a boot strap amplifier to increase input impedance. Transistors Q103 through Q106 consist of two sets of amplifiers, connected as feedback pairs. With this type of amplifier, a large amount of dc feedback is used to stabilize the operating point.

3-12. The overall gain of the amplifier is approximately 75db. The maximum signal output, however, is limited to approximately 1 vrms. The gain can vary with transistor replacement. To adjust for gain variations, the value of resistor R115 may be changed. The output of the amplifier is applied to the null detector and to the auxiliary output jacks J105 and J106 through capacitor C119.

3-13. MODEL NI-3 POWER SUPPLY.

3-14. AC power is applied through switch S105 and fuse F101 to transformer T102. The secondary voltage of transformer T102 is converted to dc by full-wave rectifier CR114 and filtered by capacitors C120 and C121 and resistor R139. Zener diode CR113 regulates the output voltage.

3-15. MODEL NI-2 POWER SUPPLY.

3-16. Batteries B101 and B102, connected in parallel, supply power for the NI-2. When FUNCTION switch S103 is turned to the BAT CHK position, meter M101 is connected into a voltmeter circuit consisting of resistors R130, R131, and R138.

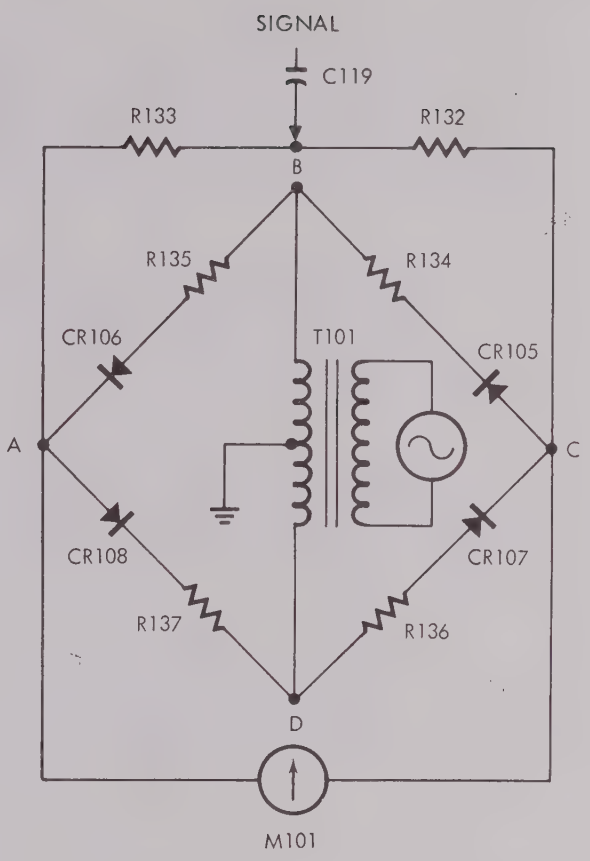


Figure 3-2. Null Detector

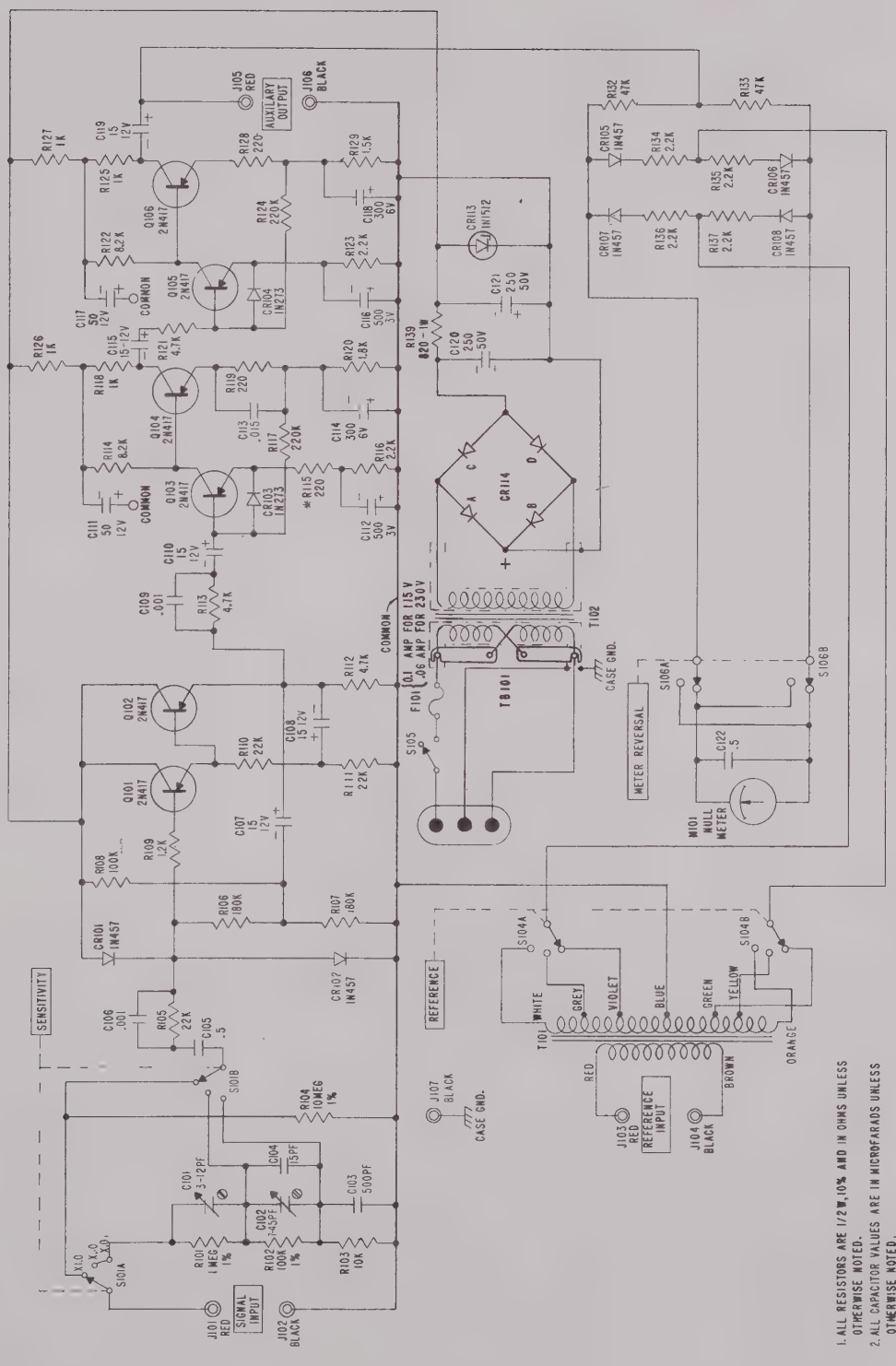


Figure 3-3. Schematic, Model NI-3

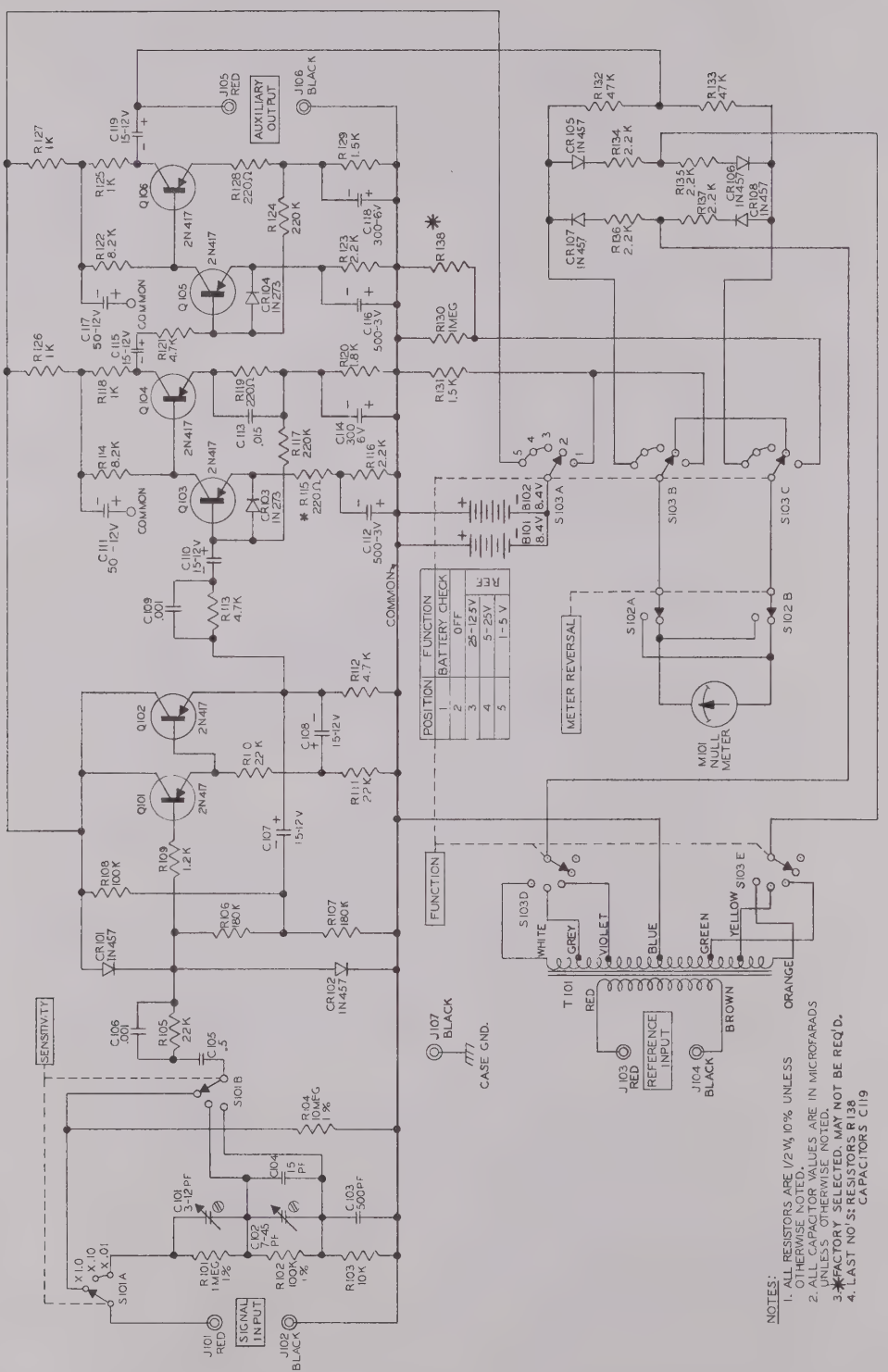


Figure 3-4. Schematic, Model NI-2

SECTION IV
MAINTENANCE

4-1. POWER CONVERSION, MODEL NI-3.

4-2. Normally, the Model NI-3 is shipped from the factory wired for 115 vac power. To convert to 230 vac power, proceed as follows:

a. Rearrange straps on terminal board TB101 as shown in figure 4-1.

b. Replace fuse F101 with a fuse rated for 1/16 amps.

4-3. TEST PROCEDURE.

4-4. The test procedure consists of a sensitivity test and a phase adjustment procedure. The following test equipment (or suitable equivalent) is required:

Signal Generator	Hewlett-Packard Model HP200CD
AC Ratio Standard	Gertsch Model 1011
Oscilloscope	Tektronix Type 503 (or equivalent)

4-5. SENSITIVITY TEST.

a. Connect power cord to a 115(±10) or 230(±20) vac power source and turn POWER switch ON. Allow approximately one minute warmup.

b. Connect null indicator into test setup as shown in figure 4-2.

c. Adjust signal generator to produce 10 vac at 50 cps.

d. Set both ac ratio standards to a reading of 0.500000.

e. Turn REFERENCE switch to 5-25v position.

f. Turn SENSITIVITY switch to X1.0 position.

g. Set ac ratio standards No. 2 to a reading of 0.500001.

h. The null meter shall deflect approximately one-half of a scale division from the center null position.

i. Turn SENSITIVITY switch to X.10 position.

j. Set ac ratio standard No. 2 to a reading of 0.500010.

k. Verify that the null meter deflects approximately one-half of a scale division from the center null position.

l. Turn SENSITIVITY switch to X.01 position.

m. Set ac ratio standard No. 2 to a reading of 0.500100.

n. Verify that the null meter deflects approximately one-half of a scale division from the center null position.

o. Repeat steps e through n with the signal generator adjusted to produce 10 vac at 400 cps, 10 vac at 1000 cps, 10 vac at 5000 cps, and 10 vac at 10,000 cps.

4-6. PHASE ADJUSTMENT.

a. Connect power cord to a 115(±10) or 230(±20) vac power source and turn POWER switch ON. Allow approximately one minute warmup.

b. Connect null indicator into test setup as shown in figure 4-3. Connect the vertical input of the oscilloscope to the auxiliary output jacks J106 and J105.

c. Adjust signal generator to produce 10 vac at 10 kc.

d. Set ac ratio standard to a reading of 0.000050.

e. Turn REFERENCE switch to 5-25v position.

f. Turn SENSITIVITY switch to X.10 position.

g. Increase setting of the ac ratio standard to a point where the oscilloscope indicates an overload, see figure 4-4.

h. Decrease setting of the ac ratio standard to a point where the oscilloscope indicates that the overload has been eliminated.

i. Adjust the oscilloscope to obtain an in-phase Lissajous pattern. Adjust capacitor C101 for a minimum phase shift indication on the oscilloscope.

j. Turn SENSITIVITY switch to the X.01 position.

k. Adjust capacitor C102 for a minimum phase shift indication on the oscilloscope.

l. Turn SENSITIVITY switch to the X.10 position.

m. Repeat steps i through l to obtain the best compromise between the two-phase adjustments.

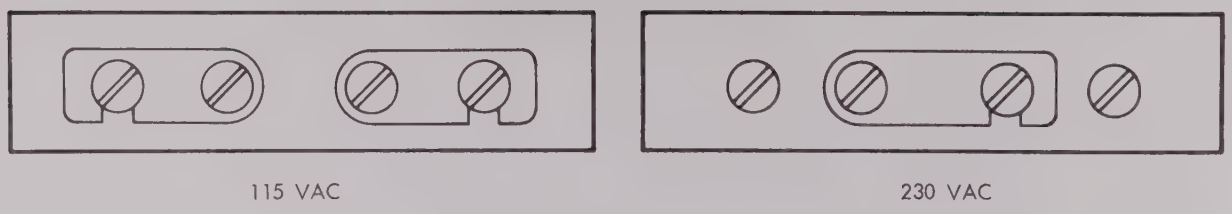


Figure 4-1. VAC Power Connections

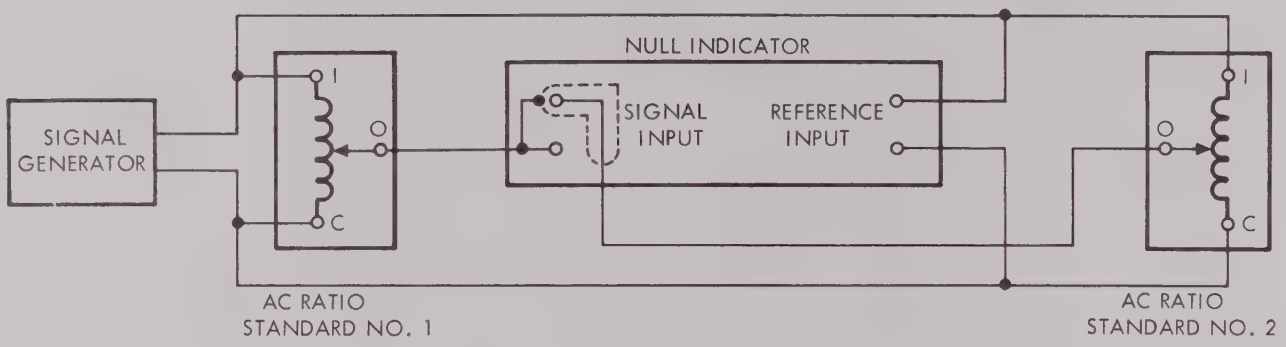


Figure 4-2. Sensitivity Test Setup

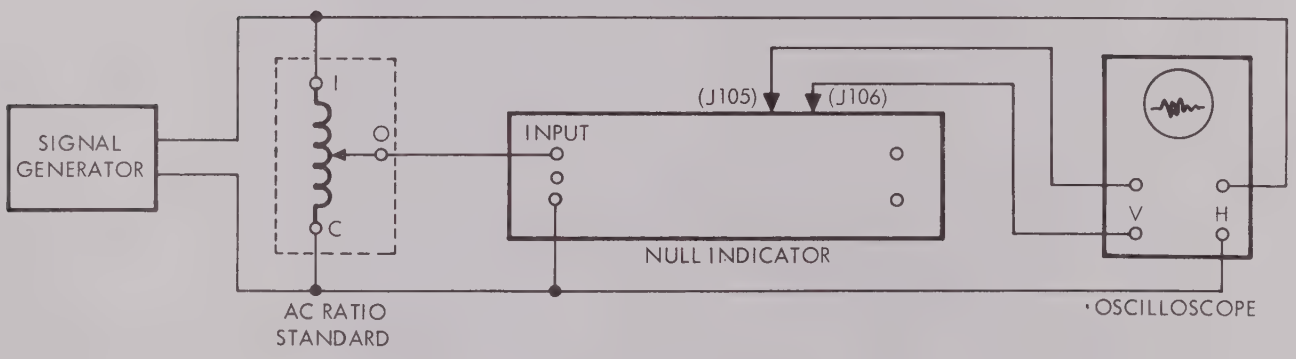


Figure 4-3. Phase Adjustment Test Setup

Figure 4-4. Phase Adjustment Overload Indication

SECTION V
PARTS LIST

SYMBOL	DESCRIPTION	MANUFACTURER	PART NO.
B101	Battery (NI-2 only) 8.4 V	Mallory	TR146R
B102	Battery (NI-2 only) 8.4 V	Mallory	TR146R
C101	Capacitor, trimmer ceramic, 3-12 pF	Erie	503NP03-12
C102	Capacitor, trimmer ceramic, 7-45 pF	Erie	503N5007-45
C103	Capacitor, silvered mica, 500 pF	El-Menco	DM15E501K
C104	Capacitor, tubular ceramic, 15 pF	Centralab	TCZ15
C105	Capacitor, metallized paper, 5 uf 200 V	Hopkins	P52DS
C106	Capacitor, disc ceramic, 0.001 uf 500 V	Erie	861Z5U102Z
C107	Capacitor, electrolytic, 15 uf 12 V	Sprague	TE1129
C108	Capacitor, electrolytic, 15 uf 12 V	Sprague	TE1129
C109	Capacitor, disc ceramic, 0.001 uf 500 V	Erie	861000Z5U0102Z
C110	Capacitor, electrolytic, 15 uf 12 V	Sprague	TE1129
C111	Capacitor, electrolytic, ~~15~~ 50 uf 12 V	Sprague	TE~~1129~~ 1133
C112	Capacitor, electrolytic, 500 uf 3 V	Sprague	TE1068
C113	Capacitor, mylar, 0.015 uf 200 V	Goodall	663UW-015UF200V
C114	Capacitor, electrolytic, 300 uf 6 V	Sprague	TE1106
C115	Capacitor, electrolytic, 15 uf 12 V	Sprague	TE1129
C116	Capacitor, electrolytic, 500 uf 3 V	Sprague	TE1068
C117	Capacitor, electrolytic, ~~15~~ 50 uf 12 V	Sprague	TE~~1129~~ 1133
C118	Capacitor, electrolytic, 300 uf 6 V	Sprague	TE1106
C119	Capacitor, electrolytic, 15 uf 12 V	Sprague	TE1129
C120	Capacitor, electrolytic (NI-3 only) 250 uf 50 V	Sprague	TVA1312
C121	Capacitor, electrolytic (NI-3 only) 250 uf 50 V	Sprague	TVA1312
C122	Capacitor, metallized paper (NI-3 only) 0.5 uf 200 V	Hopkins	P52DS
CR101	Diode, silicon	Hughes	1N457
CR102	Diode, silicon	Hughes	1N457
CR103	Diode, germanium	Transitron	1N273
CR104	Diode, germanium	Transitron	1N273

SYMBOL	DESCRIPTION	MANUFACTURER	PART NO.
CR105	Diode, silicon	Hughes	1N457
CR106	Diode, silicon	Hughes	1N457
CR107	Diode, silicon	Hughes	1N457
CR108	Diode, silicon	Hughes	1N457
CR113	Diode, Zener (NI-3 only)	International Rectifier	1N1512
CR114	Rectifier Bridge (NI-3 only)	Semtech	EP46-1
F101	Fuse, 115 V operation (NI-3 only) 1/10 AMP	Bussmann Mfg.	MDL 1/10
F101	Fuse, 230 V operation (NI-3 only) 1/16 AMP	Bussmann Mfg.	MDL 1/16
J101	Post, binding, red	Superior Electric	DF30RC
J102	Post, binding, black	Superior Electric	DF30BC
J103	Post, binding, red	Superior Electric	DF30RC
J104	Post, binding, black	Superior Electric	DF30BC
J105	Jack, test, red, banana	Johnson	108903
J106	Jack, test, black, banana	Johnson	108902
J107	Post, binding, black	Superior Electric	DF30BC
M101	Meter, null	Gertsch	AW262
P101	P/O Power Cord (NI-3 only)	Belden	17406S
Q101	Transistor	TUNG-SOL	2N417
Q102	Transistor	TUNG-SOL	2N417
Q103	Transistor	TUNG-SOL	2N417
Q104	Transistor	TUNG-SOL	2N417
Q105	Transistor	TUNG-SOL	2N417
Q106	Transistor	TUNG-SOL	2N417
R101	Resistor, deposited carbon, 1 Meg 1%, 1/2W		RN65B1004F
R102	Resistor, deposited carbon, 100K 1% 1/2W		RN65B1003F
R103	Resistor, composition, 10K 10% 1/2W		
R104	Resistor, deposited carbon, 10 Meg 1% 1/2W	IRC	MDC1005F
R105	Resistor, composition, 22K 10% 1/2W		
R106	Resistor, composition, 180K 10% 1/2W		
R107	Resistor, composition, 180K 10% 1/2W		
R108	Resistor, composition, 100K 10% 1/2W		

SYMBOL	DESCRIPTION	MANUFACTURER	PART NO.
R109	Resistor, composition, 1.2K 10% 1/2W		
R110	Resistor, composition, 22K 10% 1/2W		
R111	Resistor, composition, 22K 10% 1/2W		
R112	Resistor, composition, 4.7K 10% 1/2W		
R113	Resistor, composition, 4.7K 10% 1/2W		
R114	Resistor, composition, 8.2K 10% 1/2W		
R115	Resistor, composition, selected value (220 ohms 10% 1/2W NOM)		
R116	Resistor, composition, 2.2K 10% 1/2W		
R117	Resistor, composition, 220K 10% 1/2W		
R118	Resistor, composition, 1K 10% 1/2W		
R119	Resistor, composition, 220 ohms 10% 1/2W		
R120	Resistor, composition, 1.8K 10% 1/2W		
R121	Resistor, composition, 4.7K 10% 1/2W		
R122	Resistor, composition, 8.2K 10% 1/2W		
R123	Resistor, composition, 2.2K 10% 1/2W		
R124	Resistor, composition, 220K 10% 1/2W		
R125	Resistor, composition, 1K 10% 1/2W		
R126	Resistor, composition, ~~470 ohms~~ 1K 10% 1/2W		
R127	Resistor, composition, ~~470 ohms~~ 1K 10% 1/2W		
R128	Resistor, composition, 220 ohms 10% 1/2W		
R129	Resistor, composition, 1.5K 10% 1/2W		
R130	Resistor, composition, (NI-2 only) 1M 10% 1/2W		
R131	Resistor, composition, (NI-2 only) 1.5K 10% 1/2W		
R132	Resistor, composition, 47K 10% 1/2W		
R133	Resistor, composition, 47K 10% 1/2W		
R134	Resistor, composition, 2.2K 10% 1/2W		
R135	Resistor, composition, 2.2K 10% 1/2W		
R136	Resistor, composition, 2.2K 10% 1/2W		
R137	Resistor, composition, 2.2K 10% 1/2W		
R138	Resistor, composition, (NI-2 only) Factory selected, may not be required		

SYMBOL	DESCRIPTION	MANUFACTURER	PART NO.
R139	Resistor, composition, (NI-3 only) 820 ohms 10% 1W		
S101	Switch, rotary, 1 wafer	Gertsch	SW92
S102	Switch, slide, DPDT (NI-2 only)	Continental Wirt	SW-726
S103	Switch, rotary, 3 wafer (NI-2 only)	Gertsch	SW72
S104	Switch, rotary (NI-3 only)	Gertsch	SW92
S105	Switch, toggle (NI-3 only)		ST26N
S106	Switch, toggle (NI-3 only)		ST26N
T101	Transformer, reference input	Gertsch	TA165
T102	Transformer, power (NI-3 only) 115/230 V primary	Gertsch	TA262
TB101	Terminal board with two links (NI-3 only) 115/230 V	Gertsch	AA834
XF101	Fuseholder, 3AG MINIATURE (NI-3 only)	Littelfuse	342004
	Connector, battery (2 required) (NI-2 only)	Ucinite	154993-SA
	Knob, switch (2 required)	Gertsch	AA537

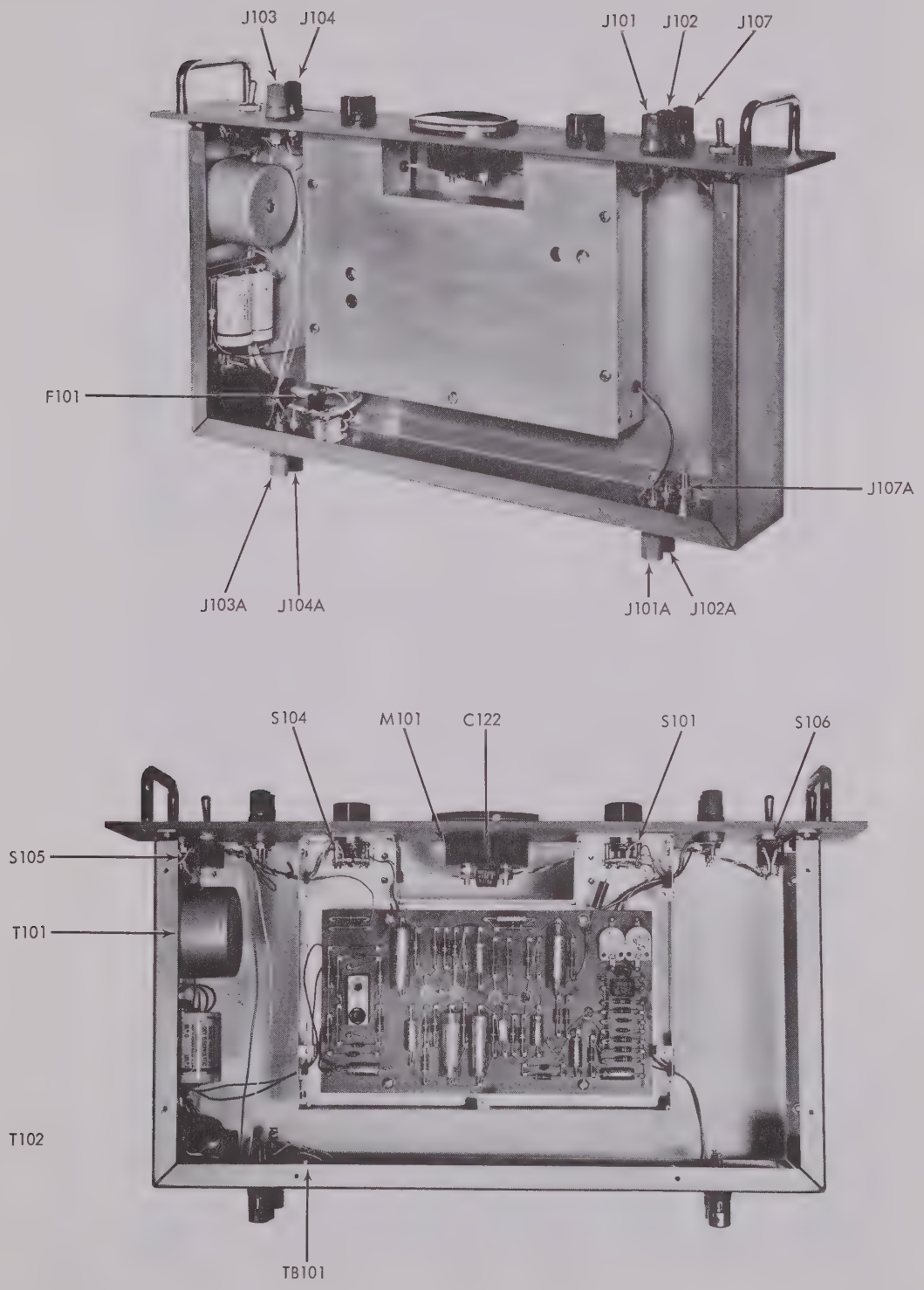
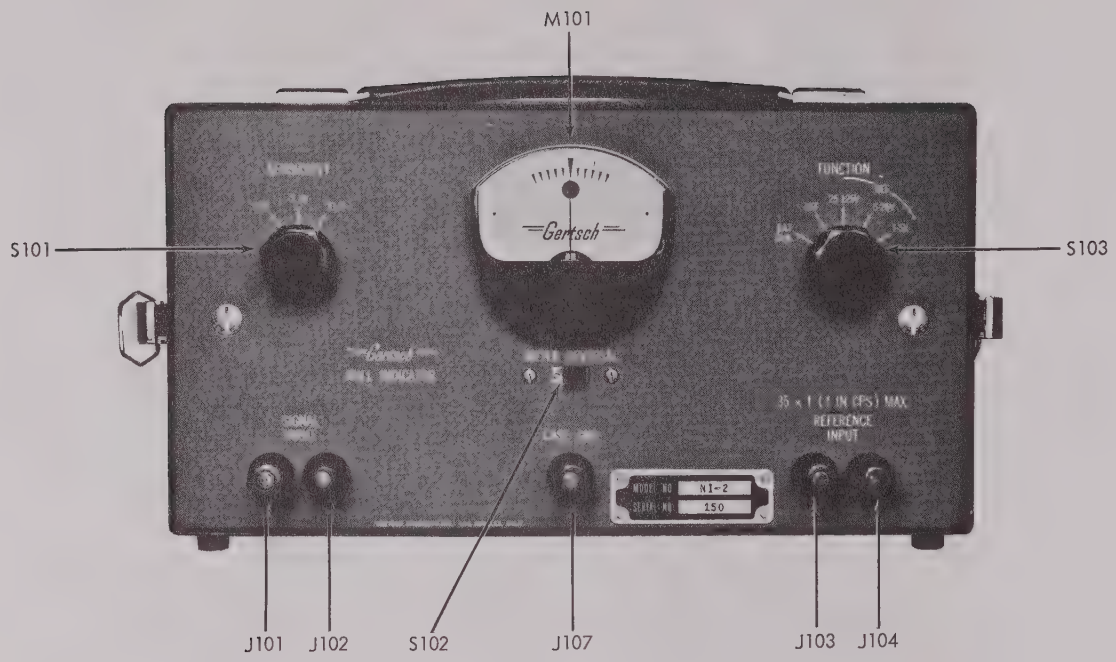


Figure 5-1. Location of Components, Model NI-3



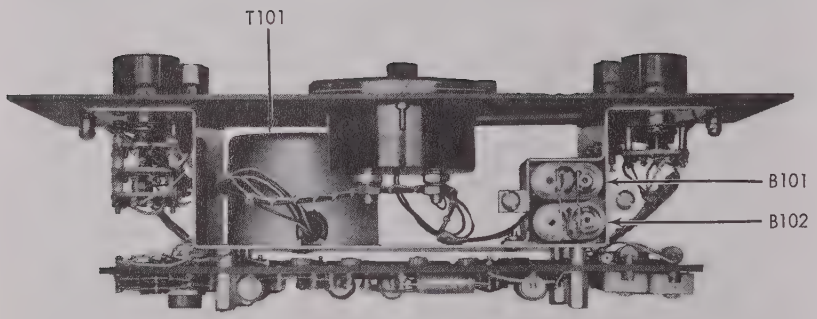


Figure 5-2. Location of Components, Model NI-2

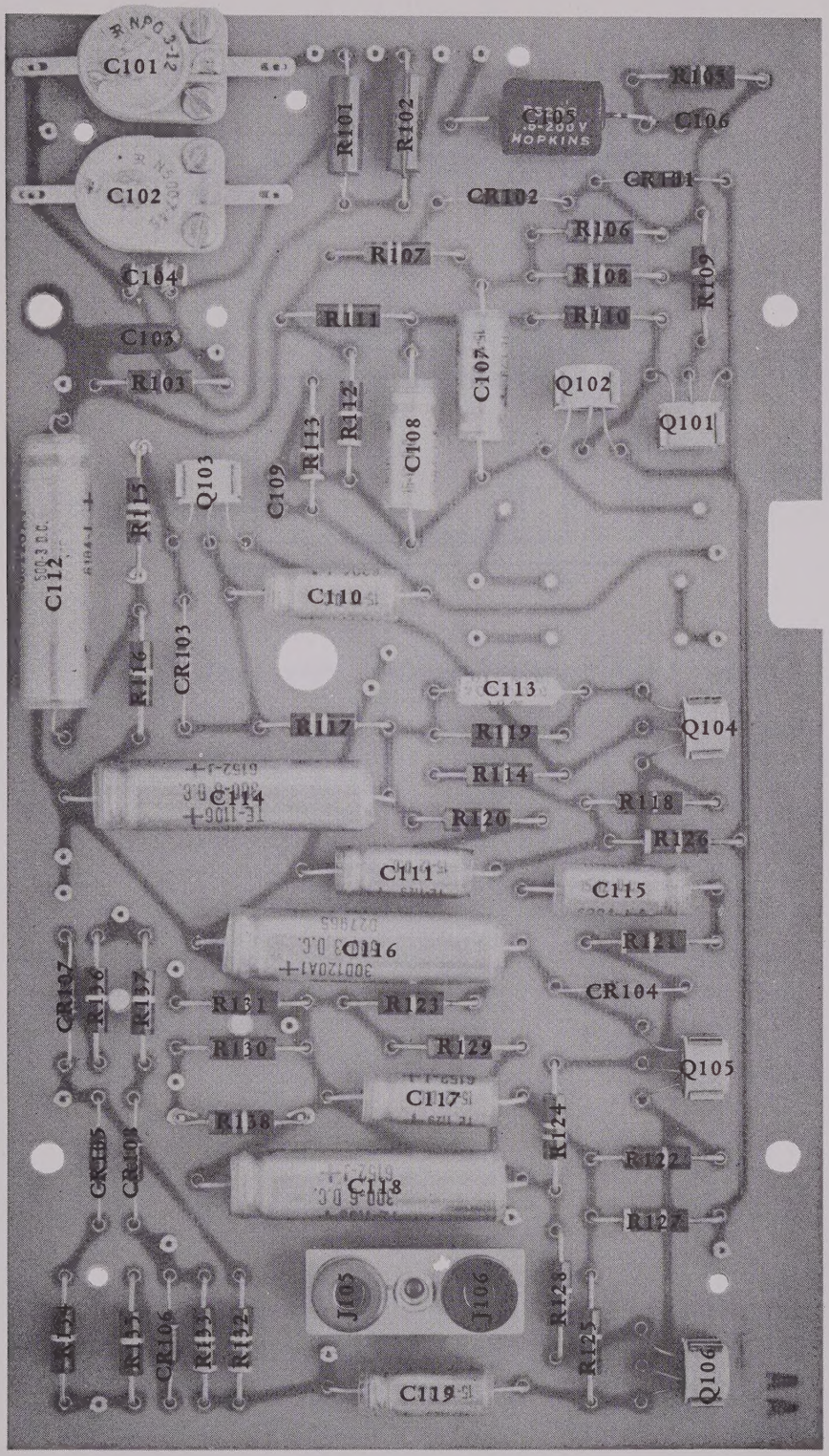


Figure 5-3. Location of Components, Null Amplifier Board

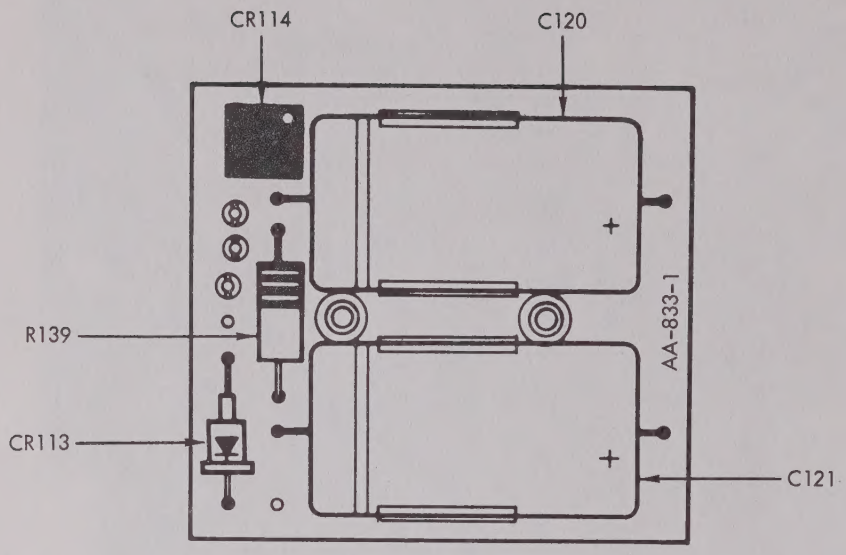


Figure 5-4. Location of Components, Power Supply Board

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